DRAFT

Approach to Integrated Technical Studies in Support of the Comprehensive BDCP Conservation Strategy

November 12, 2008

The BDCP Steering Committee is developing a comprehensive BDCP conservation strategy. The process for the development of such a strategy includes:

- Task 1. A suite of focused technical studies designed to evaluate the relationship between habitat restoration, and other stressor reduction measures, and water management measures;
- Task 2. Exploratory evaluations of a broad range of water management scenarios; and
- Task 3. Integration of findings under the focused studies and exploratory water management scenarios to develop a comprehensive BDCP conservation strategy.

The approach outlined in this document details the development of technical studies and model preparation to support these tasks. The approach does not attempt to address all necessary studies for the BDCP process, but rather focuses on the most critical elements that are needed to support the development of a broad conservation strategy. A parallel effort is underway to initiate the second round of CalLite exploratory evaluations.

Technical Study #1: North Delta Diversion Effects on Survival in North Delta Channels

This study will provide information to assist in developing North Delta conservation measures such as diversion facility bypass flow requirements, diversion facility operations, and synergies between habitat restoration and reduced threat of North Delta mortality.

Diversions at the proposed North Delta diversion facility would decrease flows in the Sacramento River and downstream distributaries, Sutter Slough, Steamboat Slough, Georgiana Slough, and the Delta Cross Channel. Strong relationships exist between Sacramento River flows, Delta Cross Channel Gate operations, and flows in these distributaries. North Delta diversions could increase the extent of bi-directional flows, decrease velocities, and increase residence time in these channels. Sutter and Steamboat Sloughs are considered important migratory pathways for juvenile salmon, while Georgiana Slough and Delta Cross Channel are considered problematic due to high levels of predation and potential entrainment. This study will evaluate the effects of the North Delta diversions on changes in North Delta hydrodynamics and attempt to relate these changes to potential changes in mortality-survival. Portions of this analysis have been developed through the HOTT process, but require more complete synthesis and additional supporting evaluations.

Task 1. Quantify observed relationship between Sacramento River and distributary flows

Preliminary evaluations of observed flow in the Sacramento River, Delta Cross Channel Gate operations, and Sutter and Steamboat Slough flows have been assessed by Richard Denton, CH2M HILL, and others. A long-standing relationship between Sacramento River flow, Delta Cross Channel gate operations, and Delta Cross Channel and Georgiana Slough flows has been confirmed through recent analysis by Jon Burau at the USGS. These relationships need to be synthesized and documented in a single document to provide the foundation for assessing future changes.

Task 2. Evaluate effects of tidal marsh restoration on North Delta hydrodynamics

Restored tidal marsh in the North Delta (primarily Cache Slough area) has been found to reduce the tidal influence on the Sacramento River near Hood and Sutter and Steamboat Sloughs. Preliminary analysis has shown similar changes due to the flooding of Liberty Island. This analysis will need to be reviewed and fully documented to present the changes in tidal flows, velocities, stage, and residence time in these distributaries under proposed tidal marsh restoration areas. The focus on this analysis should be largely limited to the North Delta tidal marsh areas as their influence in considerable.

Task 3A. Refine simulation of North Delta diversions (Phase 1, late 2008)

The Conveyance Working Group appears to moving down a path to support multiple intake locations in the North Delta, rather than a single point of diversion. Model simulations to date have only considered a single point of diversion. In addition, the modeling has not been completed to incorporate a fully-dynamic simulation based on fish screen criteria and downstream bypass requirements. A focused meeting between key technical staff of the Fish Facilities Team, or Value Engineering team, and the modeling teams is necessary to have a common understanding of the current thinking of the diversion facilities and their operation. A brief document will be prepared to describe North Delta diversion facility assumptions for use in modeling.

Hydrodynamic modeling will need to be phased. In the first phase, the DSM2 model will be configured to incorporate the distribution and operation of multiple North Delta diversion locations. Both fish screen criteria and bypass flow requirements will be incorporated into the configuration of the model simulation. North Delta bathymetry will not be updated in this phase.

Task 3B. Refine simulation of North Delta diversions (Phase 2, early 2009)

In the second phase, which will need to be performed in early 2009, refined modeling will need to be developed to better understand the near-field changes in flows, velocities, secondary currents at channel junctions and near fish screens, regions of erosion and deposition, and flood impacts. The use of existing one or two dimensional hydrodynamic models, such as DSM2 and RMA2 cannot fully resolve the complex three-dimensional flow structures in river bends or channel intersections. An appropriate three-dimensional model (such as SI3D, UnTRIM, or RMA-10) would be applied over a defined portion of the Sacramento River (likely Freeport to Walnut Grove or Rio Vista). The model domain would be limited such that more resolution could be applied to targeted areas of concern. The

model domain boundaries could be placed at historic data collection sites, or boundary conditions (time series of flows and water levels) can be supplied from DSM2 simulations.

In addition, the new model application should incorporate the most updated bathymetry for the Sacramento River. Model geometry can be developed from the bathymetric datasets contained in DWR's Cross Section Development Program (CSDP). Cross sectional channel surveys are available for the project reach. A second source of bathymetric data is DWR's Levee Survey Program, which conducted detailed bathymetric surveys in the upper Sacramento River. Depending on the extent of coverage available from the Levee Survey, additional detailed hydrographic survey data may be required. It likely that additional surveys will be needed between Freeport and Rio Vista. Calibration datasets would have to be collected through deployment of acoustic Doppler current profilers at select locations in the project reach. It is believed that much of this information may be available through the on-going fish migration study.

Task 4. Evaluate combined effects of North Delta diversion and tidal marsh restoration on North Delta hydrodynamics

The combined effect of restored tidal marsh in the North Delta *and* operation of North Delta diversion facilities would be evaluated in this task. Tidal marsh is expected to reduce the tidal influence in the Sacramento River near Hood, while the diversions will reduce net flows in the region. Initial analyses will need to be reviewed, supported with more detailed analyses, and fully documented to present the changes in tidal flows, velocities, stage, and residence time in these distributaries. The focus on this analysis should be largely limited to the North Delta (and perhaps Suisun Marsh) tidal marsh areas as their influence in considerable, while South Delta tidal marsh influence is limited to the nearby channels.

Task 5. Evaluate changes in survival with combined effects of North Delta diversion and tidal marsh restoration

The on-going salmon migration and survival study being conducted by the USGS will provide quantitative information regarding salmon route selection and survival through the mainstem Sacramento River from Freeport to Rio Vista and through Sutter, Steamboat, and Georgiana Sloughs. This information, along with previous studies, will allow for quantitative, comparative estimates of the changes in survival due to the North Delta diversion and habitat restoration considered in the BDCP. Preliminary analysis can be conducted during 2008 based on existing data and studies. However, the current USGS study will not be completed until early 2009 and it is recommended that the analyses be updated when this information is available.

Task 6. Evaluate effects of changes in channel geometry or channel junction configuration

The possibility exists that relatively small changes in channel geometry and channel junction configuration may influence the velocity fields, transport mechanisms, route selection, and ultimately the survival of migratory fish in Sutter, Steamboat, and Georgiana Sloughs. The on-going salmon migration and survival study being conducted by the USGS may provide clues related to the behavioral or hydraulic triggers related to route selection. This task will evaluate the effects of subtle changes to the channels and junctions on net and tidal flows,

velocities, and transport on these distributaries and assess the potential range of impacts on survival.

Task 7. Evaluate effects of other measures to increase survival in the North Delta

Other stressor reduction measures such as predator control, invasive species control, and channel margin habitat restoration will have some effect on the ultimate survival of covered species in the North Delta channels. This task will include a qualitative assessment of the potential influence of these measures on survival of covered species.

Task 8. Prepare technical memorandum documenting methods, assumptions, analysis, and findings

A brief technical memorandum will be prepared documenting the methods, assumptions, analysis, and findings of this study. Key findings will be included in a one-page executive summary for ease of management review.

Technical Study #2: Evaluation of North Delta Migration Corridors

This study is necessary to understand the tradeoffs between North Delta migration corridors and will provide information to assist in developing North Delta conservation measures such as increased inundation of the Yolo Bypass through modifications to the Freemont Weir.

Proposed modifications to the Freemont Weir-Yolo Bypass and the creation of Deep Water Ship Channel Bypass could lead to increased growth and survival of salmonids and other anadromous fish. It is also anticipated that these alternate migration corridors could reduce the potential impacts of a North Delta diversion facility on fish migration in the mainstem Sacramento and its lower distributaries. This study would evaluate the range of increased inundation frequencies of these two bypasses and translate these changes to rates of growth and survival. Comparisons, either quantitative or qualitative, will be made to evaluate the relative effects of the benefits of the North Delta corridors with the potential adverse effects of the North Delta diversion facility on existing corridors.

Task 1. Evaluate increased frequency and extent of inundation of North Delta corridors

Considerable work has already been performed evaluating the increased frequency of spills in the Yolo Bypass and potential extent of inundation, water depth, and velocities at varying flow rates. A similar analysis has been performed for the proposed Deep Water Ship Channel weir and bypass, although the lack of specific details related to the area of inundation limited the level of detail in this analysis. It is proposed to complete the existing draft technical memorandum to fulfill this task.

Task 2. Estimate increased growth and survival through North Delta corridors

The enhancement of the North Delta corridors, through modifications to the Freemont Weir and the creation of a Deep Water Ship Channel bypass, could increase growth and survival of salmonids and other anadromous fish. Several previous studies such as Summer et al, (2007) have described relationships for which quantitative estimates of increased growth and survival could be developed. This task will attempt to synthesize the inundation frequencies derived in Task 1 with the growth and survival relationships.

Task 3. Compare increased growth and survival through North Delta corridors with expected increased predation and mortality in North Delta channels (mainstem Sacramento River, Sutter, Steamboat, Georgiana, DCC)

The expected increased growth and survival of salmonids through alternative North Delta corridors such as the Yolo Bypass and the proposed Deep Water Ship Channel Bypass needs to be compared to the expected increased predation and mortality in the mainstem Sacramento River and Sutter, Steamboat, and Georgiana Sloughs. Methods will need to be developed to provide quantitative or qualitative comparisons on the relative cumulative impacts of these changes.

Task 4. Prepare technical memorandum documenting methods, assumptions, analysis, and findings

A brief technical memorandum will be prepared documenting the methods, assumptions, analysis, and findings of this study. Key findings will be included in a one-page executive summary for ease of management review.

Technical Study #3: Evaluation of Entrainment at South Delta Diversion

This study will provide information to assist in developing South Delta conservation measures such as limits on Old and Middle River flows, San Joaquin River near Prisoner's Point flows, or South Delta exports and will be an essential element to understand tradeoffs between North and South Delta operations.

Entrainment at the South Delta diversion leads to entrainment and mortality of covered species. A new diversion point in the North Delta with state of the art fish screens could reduce entrainment in the South Delta. Much analysis has already been performed through the HOTT process, but the previous studies need to be synthesized and augmented to complete the objectives of this assessment.

The DSM2 particle tracking model (DSM2-PTM) will be used to assess the levels of particle entrainment at the South Delta diversions. The DSM2-PTM applies the assumption of neutrally-buoyant particles and is useful in evaluating the transport and fate of non-volitional life-stage fish, larvae, plankton, and nutrients. Entrainment of volitional life-stage fish such as adult salmon will need to be inferred by biologists from changes in flow magnitudes and patterns, as the neutrally-buoyant assumption is less applicable.

In order to complete the technical study, the following steps will be performed.

Task 1. Identify a range of representative hydrologic and hydrodynamic conditions

In an effort to best estimate the change in future entrainment, it is important to select periods that are representative of the range of future hydrologic and hydrodynamic conditions. Previous analyses selected three representative periods based on the range (50th, 75th, and 90th percentile) of observed combined Old and Middle River flows. This range of flows is considered representative, but the period selection may be altered from previous analyses so that the flows are more stable over the 45-day period. Up to three additional periods may be selected in order to facilitate a broader assessment of relationships between flow conditions and entrainment. In addition, the selected periods will be limited to those in during December through June.

Task 2. Identify a range of South Delta diversions at various North Delta diversion levels

Total SWP and CVP exports, as observed in the historical periods, will be maintained in these studies. However, the distribution of diversions between South Delta and North Delta will be modified. Using first less-restrictive North Delta bypass requirements, then more restrictive requirements, North Delta diversion levels will be assessed. The remaining export will be assumed to be diverted at the South Delta. Previous analyses have shown that the South Delta diversion levels will range from 2,000 cfs to 10,000 cfs under these assumptions.

Task 3. Develop PTM simulations for broad distribution of release locations

CH2M HILL has selected twenty-eight (28) different particle release locations in order to have a broad sampling of spatial entrainment effects. These release locations include those used in Kimmerer and Nobriga (2007) and add greater detail in the South Delta and San Joaquin River. Particles will be released at each of the locations, for each of the selected periods, and the fate at "South Delta Exports" and "Past Chipps" will be tracked. These PTM simulations will be repeated for both historical conditions and for the two North Delta diversion levels.

Task 4. Analyze changes in entrainment and relationship between entrainment and exports

Analysis of the PTM results will allow quantification of particle entrainment changes under a dual North Delta-South Delta diversion facility operation. The changes in entrainment will be calculated for each of the periods and diversion distribution. In addition, the results will be analyzed to identify relationships or thresholds between South Delta export levels and entrainment for varying regions of the Delta. Previous analyses, as well as observed salvage, have suggested that entrainment has a non-linear relationship with South Delta exports and San Joaquin flows. These relationships will be evaluated and documented in this assessment. Initial modeling will characterize the effects of an open South Delta, but other options such as an "Isolated Old River" corridor may be considered to reduce entrainment.

Task 5. Perform biological evaluation of entrainment based on simulated particle entrainment

The PTM analysis will provide estimates of the range of particle entrainment. However, fish, larvae, and nutrients are not necessarily neutrally-buoyant particles. In this task, quantitative (or qualitative) assessments of species entrainment would be made performed based on the results of the modeling studies. The assessment should describe the anticipated changes in entrainment of various species and life-stages and provide a discussion of s relationship to proposed habitat restoration in the South Delta.

Task 6. Prepare technical memorandum documenting methods, assumptions, analysis, and findings

A brief technical memorandum will be prepared documenting the methods, assumptions, analysis, and findings of this study. Key findings will be included in a one-page executive summary for ease of management review.

Technical Study #4: Evaluation of Tidal Marsh Restoration Effects

This study will provide information to assist in the development of Tidal Marsh Habitat conservation measures and will assess the anticipated changes of tidal marsh to habitat and operations parameters.

Restoration of tidal marsh has been proposed for various regions of the Delta to improve habitat diversity and food for covered species. Preliminary assessments of tidal marsh effects on flows and stage have been performed for the areas in South Delta, North Delta, and East Delta. While significant technical assessments have been performed by RMA for the Suisun Marsh PEIR, the extent being considered by the BDCP is believed to be significantly larger. The feasible extent of tidal marsh needs to be evaluated in greater detail for each of these areas. The effects of tidal marsh on localized and Delta-wide food and habitat, including water quality, residence time, temperature, X2, and other parameters needs to be evaluated.

Task 1. Identify and delineate restoration areas in each region of the Delta

Preliminary delineations of restoration areas have been prepared for the North Delta, South Delta, and East Delta. These delineations need to be confirmed and characterized as tidal marsh, floodplain, or other types of habitat. In addition, proposed Suisun Marsh restoration areas need to be delineated and synthesized with that being considered in the Suisun Marsh PEIR. Preliminary modeling results should be analyzed to determine the *actual* extent of tidal marsh after considering tidal dampening. New areas may be suggested if the feasible marsh areas are significantly changed from that desired.

Task 2. Develop one- and two-dimensional hydrodynamic simulations of tidal marsh

One-dimensional model simulations of tidal marsh effects have been performed using the DSM2 model and "reservoir-construct" for the North, South, and East Delta. This implementation is a simplified approach to a process that is better represented with multi-dimensional analyses. CH2M HILL and RMA have developed a preliminary work plan that involves the use of the RMA2 model for tidal marsh assessments in the Suisun Marsh, North Delta, and South Delta. The RMA2 model would be configured to represent these areas and can simulate in greater detail the impacts in the marsh and nearby channels. RMA2 model, however, is generally used to simulate periods of months to one-year. The simulated effects produced by the RMA2 and DSM2 models will be compared, and the DSM2 tidal prism volumes and friction coefficients may be modified depending on the comparison. This hybrid-approach will give greater credibility to the assessments while retaining the ability to perform longer simulations for a larger number of alternatives.

Task 3. Analyze results for changes to flows, velocities, stage, water quality, and residence time

Results from the RMA2 and DSM2 models will be analyzed for changes to flows, velocities, stage, water quality, and residence time. Maps will be created to spatially demonstrate changes in mean and tidal velocities, salinity distribution changes, and residence time changes. In addition, particle tracking results will be demonstrated through the use of "fate maps" which will show the fate of particles released at locations throughout the Delta. Residence time and salinity will be evaluated and can provide useful information related habitat suitability and nutrient impacts.

Task 4. Perform assessment of potential temperature and carbon changes

A focused analysis using the results from Task 3 as well as additional information such as air temperature and studies on carbon-cycling on representative marshes will be performed

to identify whether significant changes to water temperature and food would be expected. Water temperature has been found to largely be equilibrated with air temperature in many of the Delta channels. The effect within the tidal marsh system, however, is not yet known.

Task 5. Synthesize results to form an assessment of changes to food and habitat for covered species

Synthesize results of Task 3 and 4 into an assessment of changes to food and habitat for covered species. It is anticipated that the DRERIP conceptual models would be helpful for guiding this synthesis.

Task 6. Prepare technical memorandum documenting methods, assumptions, analysis, and findings

A brief technical memorandum will be prepared documenting the methods, assumptions, analysis, and findings of this study. Key findings will be included in a one-page executive summary for ease of management review.

Additional Technical Studies

The following other technical studies are not yet scoped.

Technical Study #5: Reduction of Ammonia Concentrations and Discharge

Technical Study #6: Reduction of Entrainment at Other In-Delta Diversions

Technical Study #7: Control of Non-Native Submerged Aquatic Vegetation

Technical Study #8: Harvest and Hatchery Population Enhancement

Technical Study #9: Control of Other Toxics including Endocrine Disruptors, Agricultural Chemicals, and Methylmercury

Technical Study #10: Control of Non-Native Predators and Competitors

Technical Study #11: Other Water Quality Issues Conservation Measures